

**EFFECT OF FIRST PREMOLAR EXTRACTION ON  
UPPER AIRWAY DIMENSION IN PATIENTS WITH  
BIMAXILLARY PROCLINATION**

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PROCLINATION**

By

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## **DEDICATION**

### **To My Great parents**

They provided me with technical advice, creative criticism and endless encouragement.

### **To My Great brothers and sister**

They supported me during the difficult times.

### **To My wonderful wife**

She was always next to me, brought the meaning, happiness and peace to my life.

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## ABSTRACT

### EFFECT OF FIRST PREMOLAR EXTRACTION ON THE UPPER AIRWAY DIMENSION IN PATIENT WITH BIMAXILLARY PROCLINATION

By

Nizar Jawad El Said

**Objective:** This was a retrospective study aimed to investigate the effect of orthodontic treatment with first premolar teeth extraction in bimaxillary proclination cases on the upper airway dimensions and to study the relationship between upper and lower arch dimensional changes and the changes in upper airway dimension.

**Materials and Methods:** Pre and post- orthodontic treatment cephalograms, and dental cast of 70 bimaxillary proclination patients were used for this study. Patients were divided into 2 groups, the first group was the extraction group and consisted of 31 patients treated with four first premolars extraction (age ranged between 18 and 23 years), and the second group was the non extraction group and consisted of 39 patients (age ranged between 18 and 23 years).

Cephalometric radiographs were used to measure the airway dimensions, and dental casts to measure the changes in the arch dimensions.

**Results:** The results of the extraction group showed statistically significant reductions in tongue length, posterior adenoids thickness (AD2-H), upper and lower incisor inclination, and lower incisor to A-Pog line. Considering the dental cast results, statistically significant reductions in upper arch length, lower arch length, and lower inter-molar width were found. The only statistically significant increase was recorded for the upper inter-canine width.

The results of the non extraction group showed statistically significant reductions in the SNA and ANB angles, and the inferior airway dimensions. Also, a statistically significant increase in the vertical air ways dimensions and the bony nasopharynx were recorded.

**Conclusions:** Premolar extraction for the treatment of bimaxillary proclination does not affect the upper airway dimensions despite the significant reduction in the tongue length. Non extraction treatment would expand the upper arch significantly which in turn may reduce the inferior uvulo-glossopharyngeal air ways dimensions significantly.

## **CHAPTER ONE: - INTRODUCTION**

### **1.1 Introduction**

Bimaxillary dental protrusion implies a particular occlusal pattern where the upper and lower incisors are proclined. The molar relationship is usually normal and as such this occlusal pattern is often considered to be a sub-set of Class I malocclusion (Gianelly and Goldman, 1971; Graber, 1972; Posen, 1972; McCann and Burden, 1996).

The etiology of bimaxillary proclination is multifactorial including a genetic component as well as environmental factors, such as mouth breathing, tongue and lip habits, and tongue volume (Lamberton *et al.*, 1980).

Many studies reported that obstructive sleep apnea patients benefited from mandibular advancement (Powell et al., 1983; Kuo et al., 1979). Turnbull and Battagel (2000) reported an increase in retropalatal and retrolingual dimensions of the airway after mandibular advancement. Okyay and Ulukaya (2008) found that maxillary protraction without rapid maxillary expansion in patients with a retrusive maxilla caused the upper airway dimensions to increase.

The goals of orthodontic treatment of bimaxillary protrusion include the retraction and retroclination of maxillary and mandibular incisors with a resultant decrease in soft tissue procumbency and convexity. This is most commonly achieved by the extraction of four premolars followed by the retraction of anterior teeth using maximum anchorage mechanics (Bills et al., 2005). This form of treatment affects the maxillary dimension.

Considering that arch expansion antero-posteriorly has a definite influence on the upper airway dimension, one can speculate that premolar extraction and retraction of the anterior segment, for the treatment of bimaxillary proclination, could affect the upper airway dimension.

The hypothesis of this study is that premolar extraction treatment in bimaxillary proclination cases will be expected to cause a decrease in upper airway dimensions.

## **1.2 Significance of the study**

It is clear from the literature that there is a significant relationship between airway dimensions and various types of orthodontic treatment, but to our knowledge there is no data about the relationship between premolar extraction for treatment of bimaxillary proclination and airway dimension. This study will be the first to investigate the effect of premolar extraction treatment of bimaxillary proclination on upper airway dimensions.

## **CHAPTER TWO:-REVIEW OF THE LITERATURE**

### **2.1. Definition:-**

Bimaxillary proclination is a condition characterized by protrusive and proclined upper and lower incisors and an increased procumbency of the lips. It is considered present if the interincisal angle is less than 125 degree, the maxillary incisors are proclined beyond 115 degree, and the mandibular incisors are proclined beyond 99 degree to the mandibular plane. (Keating, 1985)

### **2.2. Prevalence of bimaxillary proclination:-**

The prevalence of bimaxillary proclination is widely diversified and could be influenced by racial and ethnic characteristics.

Sunshner (1977) investigated 100 lateral photographs of attractiveness in blacks. He compared the blacks' profile with Ricketts, Holdaway, and Steiner and found that blacks' soft tissue profile was significantly more protrusive than whites' profile.

It has been reported that the incidence of bimaxillary proclination is higher in Africans and Asian individual (Keating, 1985; Farrow et al., 1993; Proffit, 2000).

In Arabic population, the prevalence of bimaxillary proclination varies. Sarhan and Nashashibi (1988) compared the cephalometric radiographs of Saudi boys (10–14 years of age) with a similar British sample. They found that Saudis had slightly more prognathic faces, more proclined incisors compared to the British sample. Al-Jasser (2000) compared the craniofacial characteristics of 87 Saudi students with European-American standards; he concluded that Saudis have different craniofacial features.

Hassan (2006) found that most of the adults living in the western region of Saudi Arabia have bimaxillary proclination.

Another study by Behbehan *et al.* (2006) revealed that the Kuwaitis have most of the features of bimaxillary proclination, and even more than that of white Caucasians.

Hussein and Mois (2007) in their study concluded that the Palestinian population compared to the European have proclined upper and lower incisors, and reduced inter incisal angle. However, this finding has no effect on the facial profile of the Palestinian faces.

## **2.3 Characteristics of bimaxillary proclination:**

### **2.3.1. Skeletal features**

Keating (1985) identified the common features of bimaxillary proclination in Caucasian individuals based on lateral cephalograms. He found that bimaxillary proclination was associated with bimaxillary prognathic jaws, a mild Class II skeletal pattern, a longer and more prognathic maxilla, a shorter posterior cranial base, a smaller upper and posterior face height, diverging facial planes and a procumbent soft tissue profile with a low lip line.

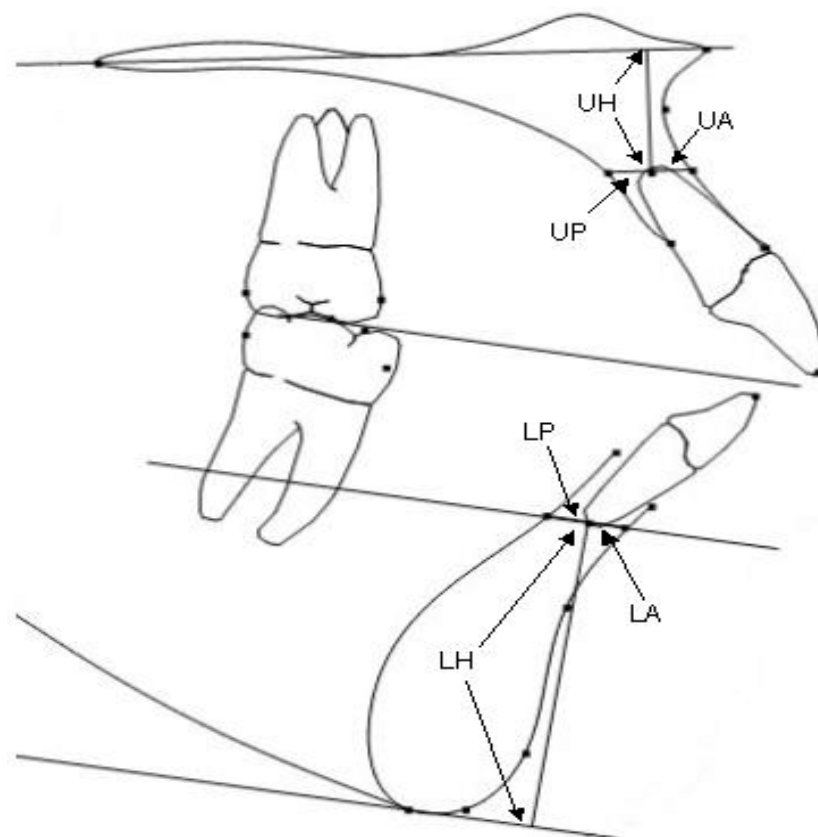
Bills *et al.* (2005) designed a study to demonstrate the cephalometric characteristics of bimaxillary proclination. They reported that the cephalometric features of those bimaxillary proclination patients include:

- 1- increased lower anterior face height.
- 2- increased maxillary mandibular planes angle.
- 3- increased upper and lower dentoalveolar heights.

The increased vertical measurements found in their study indicated that individuals with bimaxillary proclination tend to have vertical growth patterns.

Bills *et al.* (2005) also suggest that individuals with bimaxillary proclination tend to have a thin and elongated alveolus.

Handelman (1996) used the lateral cephalograms to measure upper and lower alveolar bone widths and heights (as shown in figure 2.1) and suggested that bimaxillary proclination patients tend to have thinner and longer alveolar bone.



**Figure 2.1:** Cephalometric measurements of alveolar width (Handelman, 1996)



### **2.3.2. Dental features**

Keating (1985) suggested that dentition in bimaxillary cases adapt to the underlying skeletal and surrounding soft tissues.

McCann and Burden (1996) examined tooth size in a sample of thirty Northern Irish people with bimaxillary dental protrusion. The mesiodistal diameters of all permanent teeth (excluding second and third molars) were measured. The tooth sizes were compared with a control group who did not have bimaxillary dental protrusion. The results revealed that, on average, tooth size for the overall maxillary and mandibular dentition was 5.7 *per cent* larger in the bimaxillary sample than in the control sample.

Bill *et al.* (2005) reported that patients with bimaxillary protrusion exhibited a decreased interincisal angle and much more obtuse measures of incisor inclination, when compared with their norm. The subjects also had upper and lower incisors that were extremely protrusive in an anteroposterior direction.

It is rare to find severe crowding in an individual with proclined incisors. Space analysis usually shows a small or nonexistent discrepancy, because the incisor protrusion has compensated for the potential crowding (Proffit, 2000).

### **2.3.3. Soft tissues**

The relationship between lip posture and the position of the incisors is very important indicator of how much the incisors are proclined. The teeth protrude excessively if the lips are prominent, everted, and separated at rest by more than 3 to 4 mm. In other words, excessive protrusion of the incisors is reflected by prominent lips that are separated when

they are relaxed, so that the patient tries to bring the lips together over the protruding teeth by stretching them which results in muscle strain that can be seen over the chin area (Proffit, 2000).

A study by Bills *et al.* (2005) was designed to demonstrate the cephalometric characteristics of bimaxillary proclination to reveal the skeletal, dental and soft tissue features. They reported the following soft tissue cephalometric features:-

- 1- Upper and the lower lips were ahead of the Ricketts E-plane.
- 2- nasolabial angle was more acute than that in the mixed racial norms.
- 3- increased measurements of upper and lower lip thickness

The procumbent position of the lips may be related to the fact that they included a large percentage of African-American patients in their study.

#### **2.4 Etiology of bimaxillary proclination:**

The etiology of bimaxillary proclination seems to be multifactorial and consists of genetic components as well as environmental factors, such as mouth breathing, tongue and lip habits, and tongue volume (Lamberton *et al.*, 1980).

Proffit (2000) stated that there is no doubt about the equilibrium existence , and he defined the equilibrium in the dentition by the influence of variety of forces in different directions on the teeth but the net force is zero , so the teeth remain in their stable and

balanced position most of the time . Since the teeth are surrounded by the lips and cheeks from front and the tongue from behind, the opposing forces from these tissues will play a major role in the equilibrium. These forces are called the intrinsic forces. In addition to these intrinsic forces from the lips, cheek and the tongue, the forces created within the periodontal membrane also play a role in the equilibrium.

Respiratory needs influence the head, jaw and tongue position and thereby alter the equilibrium. This is in agreement with Posen (1972) who found that children with breathing difficulties keep their mouth open, thereby the normal lip function is impeded and so the peri-oral musculature will be weak and never reach their potential strength. In this case the patient may develop a tongue thrust causing the teeth to move forward and resulting in bimaxillary proclination. Posen (1972) in his study also reported that the maximum tongue force was found to be higher than the maximum perioral forces and suggested that the tongue doesn't exert its maximum force on the dentition in the normal conditions. Otherwise, the majority of the patients will have a protrusive dentition. When he examined patient with bimaxillary proclination, he found that the maximum lip forces were significantly lower than that of the normal occlusion (no bimaxillary proclination) group. On the other hand, the maximum tongue force was found to be equivalent to that of the normal occlusion or malocclusion group (no bimaxillary proclination). Based on his findings, Posen (1972) suggested that the underlying cause for bimaxillary proclination is not the exceeded tongue pressure, but the weak perioral musculature.

## **2.5 Treatment of bimaxillary proclination**

Facial esthetics is the major concern for many of orthodontic patients. The negative impacts on the facial profile with upper lip protrusion often lead patients to seek orthodontic treatment. Increased upper lip procumbency is commonly associated with protrusive maxillary dentition in Class II Division 1 malocclusions and Class I malocclusions with bimaxillary proclination. (Langberg and Todd, 2004; Chae, 2006)

In such circumstances, the major orthodontic treatment goal is to reduce the proclination of the maxillary incisors and retroclination of maxillary and mandibular incisors with a resultant decrease in soft tissue procumbency and convexity (Bills *et al.*, 2005).

A common treatment approach for patients with severe bimaxillary proclination, facial convexity, lip incompetence, and crowding is to extract 4 first premolars and then retract the anterior teeth. (Diels *et al.*, 1995)

Langberg and Todd (2004) found out that the appropriate treatment plan for treatment of a severe bimaxillary proclination, in African patients, with procumbent upper and lower lips, proclined and protruded maxillary and mandibular incisors, deep mento-labial sulcus and excessive lip strain was with a 4-first-premolar extraction. A positive soft tissue response to treatment was achieved, the patient's profile was improved, significant retraction of the upper and lower lips was achieved, and lip eversion and dentoalveolar protrusion were significantly improved. As the lips were retracted, mentalis strain was reduced; this improved chin projection. Dentally, the interincisal angulations improved significantly because both maxillary and mandibular incisors were up righted after space closure.

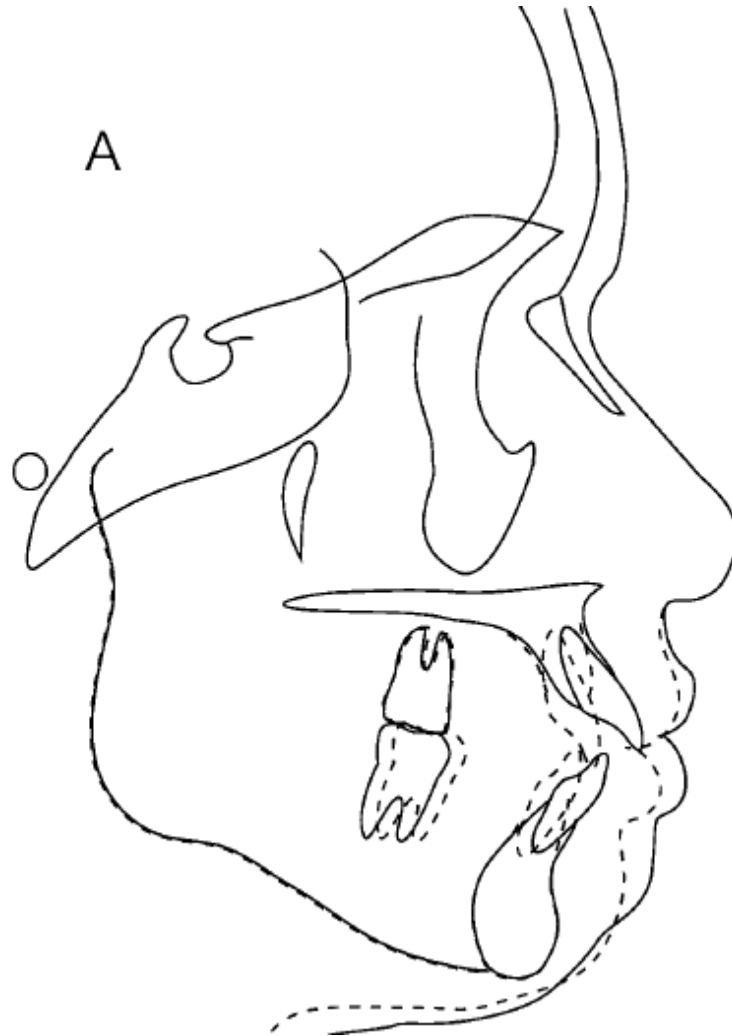
In case of treatment of bimaxillary proclination and when extracting the maxillary and mandibular first premolars is indicated to correct the malocclusion, the treatment plan

must address space closure of the extraction sites. Closure of the extraction sites can occur by retraction of the anterior segments, protraction of the posterior segments, or a combination of the two. However, mesial movement and extrusion of the maxillary posterior teeth should be restricted until the crowding and dentoalveolar proclination are resolved (Braun *et al.*, 1997).

To augment anchorage, adjunctive appliances, such as a transpalatal bar, a Nance holding arch, palatal implants, or extraoral traction, are usually necessary. Intraoral sources of anchorage include alveolar bone, teeth, dental arches, palatal and mandibular basal bone, differential movement mechanics, and lip musculature can also be useful (Rajcich and Sadow, 1997).

Yao *et al.* (2008) explored the effectiveness of skeletal anchorage during maxillary dentoalveolar retraction in adults with Class II and Class I malocclusions with bimaxillary proclination, compared with traditional extraoral anchorage by headgear. They stated that treatment of maxillary dentoalveolar proclination can be facilitated by various mini-implants, including miniplates, miniscrews, and microscrews. The results of this retrospective study showed that orthodontic treatment with skeletal anchorage achieved greater retraction of the maxillary incisors and less anchorage loss of the maxillary first molars than did traditional headgear anchorage, also demonstrated that mini-implant skeletal anchorage are highly acceptable to the adult patients since mini-implants can effectively provide stable anchorage without the need for patient compliance.

Treatment of bimaxillary proclination was achieved by incisor retraction and no anchorage loss was found. Figure (2.2)



**Figure 2.2:** Superimposition of cephalometric tracings before (solid line) and after (dotted line) treatment. (A) A best fit on the anterior wall of sella turcica, the greater wings of the sphenoid, the cribriform plate, the orbital roofs, and the surface of frontal bone. (Yao et al., 2008)

## **2.6 Premolar extraction as part of orthodontic treatment**

It has been reported that 4 first premolars are the most likely teeth to be extracted as part of orthodontic treatment (Gottlieb *et al.*, 1986). On the contrary, Ong and Woods (2001) reported that, in a randomly selected premolar extraction sample, upper 4s and lower 4s extraction accounted for only 21 *per cent* of the cases, whereas extraction of upper 4s and lower 5s and upper 5s and lower 5s accounted for 37 *per cent* and 42 *per cent* of the cases, respectively.

Although, for various reasons, many orthodontists have recommended variations in extraction sequences, including maxillary and mandibular first and/or second premolars (Brandt and Safirstein, 1975), the decision of which teeth to be extracted should be related to the amount of anterior segment retraction because the extraction site will affect the total root surface area of the teeth and there is a strong relationship between the root surface area and the anchorage potential. (Proffit, 2000)

Creekmore (1997) stated that when first premolars are extracted, two-thirds of the space will be utilized to relief crowding and retract the anterior segment, and the remaining one third will be closed by molar protraction. However, in the case of second premolar extraction, one can expect that the posterior teeth will move forward approximately half the extraction space, leaving the remaining half for the relief of crowding and retraction of anterior teeth.

Ong and Woods (2001) designed a study to examine dimensional changes in the maxillary arch following the extractions of maxillary first or second premolars by looking

at the pre and post-treatment records. The study included 71 treated cases by an experienced orthodontist and involved premolar extraction. All patients had 4 premolar extractions as part of their comprehensive orthodontic treatment. Patients with asymmetric premolar extractions within the dental arches were excluded. When relative maxillary incisor and molar movements were compared, greater molar movements occurred in the following sequence:

- 73 *per cent* of the extraction spaces closed by molar protraction in the case of upper and lower 4s extraction.
- 80 *per cent* of the extraction spaces closed by molar protraction in the case of upper 4s and lower 5s extraction.
- 81 *per cent* of the extraction spaces closed by molar protraction in the case of upper 5s and lower 5s extraction.

The above results mean that other methods of anchorage control should be used in cases of high anchorage demand, rather than depending on the differential extraction only.

Although it is clear that there are differences in the incisor behavior, like that greater incisor retraction accompanies maxillary first premolar extractions; considerable individual variations in incisor and molar movements are likely to be seen with any premolar extraction sequence. A specific extraction sequence does not necessarily seem to guarantee that certain amounts of incisor retraction or molar protraction will occur (Ong and Woods, 2001).



### **2.6.1 Premolar extraction and arch dimensional changes:**

#### ***Upper arch***

Ong and Woods (2001) studied the maxillary arch dimensional changes following extraction of first and second premolar teeth. They reported that the mean reductions in both arch depth and chordal arch length were similar in the two extraction patterns. This might have been expected because there were similar mean amounts of crowding in the two groups (3.5mm). On the other hand, they found an increase in the arch width across premolar teeth. However, inter molar width has reduced and especially in the case of second premolar extraction. This would suggest that, in clinical practice, it might be easier to maintain the initial inter molar width if second premolar extraction could be avoided.

Isik *et al.*, (2005) compared arch dimensions in 3 treated groups; the first one was treated by extraction of four first premolars, the second by non-extraction, and the third one by non-extraction and rapid maxillary expansion (RME). When comparing pre- and post-treatment values in the upper arch, they found that upper inter-canine distance increased in all treatment groups and was not affected by the treatment modality. This was in agreement with another report (Sadowsky *et al.*, 1994). Non extraction and RME expansion group exhibited 5 mm increase in the inter-premolar width which was about two-fold increase when compared to the non-extraction group. This finding was also in agreement with that reported by Adkins *et al.* (1990), who found an increase in the inter-premolar width by 6.1mm, after the use of RME. Upper inter-first premolar width in the non-extraction group without RME was increased by a mean of 2.15 mm, which is also in agreement with the 2.7 mm increase reported by Sadowsky *et al.* (1994). Intermolar arch width increased more in the non-extraction subjects when compared with those treated by

extractions, which was in agreement with Kim and Gianelly (2003) who found 1.53 mm increase in the upper inter molar width in non extraction cases and 0.53 mm decrease in the extraction cases.

### ***Lower arch***

Isik *et al.* (2005) found that the widest inter canine width was recorded in the extraction group, compared with non extraction in the lower arch. This can be explained by the distal movement of the canines to a more posterior and therefore wider position in the arch. On the other hand, non extraction group had a decrease in the inter canine width of about 0.6mm which may be as a result of slight forward movement of the canines as a result of anteroposterior expansion associated with non extraction and the fact that the arch forms being customized so as to retain the original inter-canine distance at the start of the treatment. Other studies however, reported an increase in lower inter canine width in non extraction treatment of about 0.43 mm (Kim and Gianelly, 2003).

In Isik *et al.* (2005) study, inter-premolar width in non extraction groups increased by 1.62 mm compared to the extraction group in which the width decreased by 0.95 mm as reported by Kim and Gianelly (2003). Lower inter-molar width was increased (0.81 mm) in non-extraction and decreased (0.94 mm) in extraction treatment (Kim and Gianelly, 2003). This was in agreement with Gardner and Chaconnas (1976) who reported an increase of about 1.98 mm in inter molar width in non-extraction and a decrease of about 1.49 mm in the extraction treatments.

Boley *et al.* (2003) found that in case of four premolar teeth extraction, mandibular intercanine width increased by a mean of (1.7 mm) during treatment, whereas mandibular intermolar width decreased by a mean of (2.1 mm). Arch lengths decreased during treatment because of molar protraction and incisor retraction.

### **2.6.2 The effect of premolar extraction on the lip position**

Tooth position changes by orthodontic treatment may produce desirable or undesirable changes in the soft-tissue contours. Lips are the specific areas affected.

Lip position is important because the public tends to focus more on lip changes than on changes of the nose or chin (Burcal *et al.*, 1987)

Most studies have used ratios to quantify lip response to four first premolar extraction followed by retraction of anterior segment. Ratios of maxillary incisor retraction to posterior movements of upper lip have been reported to vary from 1.2:1 to 3.2:1 (Lew, 1989).

In case of lower lip, the ratio of lower incisors retraction to posterior movement of lower lip ranges from 0.4:1 to 1.8:1. The soft-to-hard tissue responses were consistently stronger for the lower than the upper lip (Caplan and Shivapuja, 1997).

Kusnoto and Kusnoto( 2001) found that the ratio of lip retraction to the incisor retraction is 1:4, but it depends on the lip thickness; thicker lips respond less than the thinner ones.

The soft tissue to hard tissue response is different between males and females. Diels *et al.* (1995) found that the ratio of lip retraction to incisor retraction in females was 1:3.3, whereas in males the ratio was not relevant, because they responded in a different way during treatment as a result of further growth. They reported that in males the incisors moved backward but the upper lip moved forward due to growth. They suggested that this difference in lip response was due to the difference in the amount of growth between the males and females, not due o the difference in the nature of soft tissue itself. Hershey (1972) reported that the increasing variability in the soft tissue response to increased tooth

retraction suggested that the perioral soft tissues may be self-supporting, and gross tooth movement may not always mean marked reduction in the profile contour.

Wisth (1974) found that lip response, as a proportion of incisor retraction, decreased as the amount of incisor retraction increased. These results suggest that the lips have some inherent spatial, functional, and structural features.

Oliver (1982) found that patients with thin lips or a high lip strain displayed a significant correlation between incisor retraction and lip retraction; whereas patients with thick lips or low lip strain displayed no such correlation.

Luppanapornlarp and Johnston (1993) found that premolar extraction had a great impact (by 2–3 mm) on the profile of their sample. Nevertheless, they suggested that it should not be inferred that the extraction profiles were too ‘flat’. On the contrary, extraction patients more often had ‘nice, full, profiles’. This is in agreement with Young and Smith (1993), who concluded that it is incorrect to blame undesirable facial aesthetics after orthodontic treatment on extraction of premolar teeth.

Brock *et al.* (2005) in his study found that the black group showed more posterior movement of the crown than the root apex, nearly twice as much as the white group. This suggests that the black group experienced more tipping movement than white group and this means that the white group underwent more bodily movement during anterior teeth retraction. The hard and soft tissue treatment changes of the black group were more downward, and those of the white group were more backward. This suggests the existence of ethnic differences in the soft tissue response to hard tissue changes.

### **2.6.3 The effect of premolar extraction on the naso-labial angle**

Lo and Hunter (1982) designed a study to examine the changes in the nasolabial angle and lip thickness resulting from maxillary incisor retraction and compared them with changes in nasolabial angle due to growth without treatment. They also looked at the possible differences in nasolabial angle changes as a result of extraction and non extraction cases. Their sample consisted of 50 treated subjects and 43 untreated subjects, all of whom had Class II, Division 1 malocclusions. They found that nasolabial angle did not change significantly with age as a result of growth,. However, it did change significantly as a result of maxillary incisor retraction and a significant correlation was found between nasolabial angle increase and the amount of maxillary incisor retraction. In addition to that, they found that the increase in the nasolabial angle correlated significantly with treatment-related increase in the vertical dimension of the lower face.

On the contrary, other studies did not find any significant correlation between the horizontal retraction of the maxillary incisors and the increase in the nasolabial angle. (Waldman, 1982; Jamilian *et al.*, 2008;)

## **2.7 Airway dimensions**

### **2.7.1 Definition**

The pharyngeal airway is a fibro-muscular tube continuous below with the esophagus and the larynx, uncompleted anteriorly receiving the posterior opening of nasal and oral cavities. (Mcminn, 1999)

The pharyngeal airway could be divided into nasopharynx, oropharynx, and hypopharyngeal airway according to a horizontal line from the palatal plane (ANS-PNS), or mandibular plane (Me-GO) to the posterior pharyngeal wall. The nasopharynx is above

the palatal plane, the oropharynx is located between the palatal plane and mandibular plane, and the hypopharyngeal airway is below the mandibular plane (Ingman *et al.*, 2004)

### **2.7.2 The racial effect on the airway dimensions**

Bahatia (1979) studied the nasopharyngeal width in different racial groups and found that the widest bony nasopharyngeal dimension was in the Negroid group, then the austroid and Chinese groups, and the least was in white group. He found also that a wide nasopharynx is associated with a flattered nasopharyngeal roof angle.

Jones and Bahatia (1994) supported the racial differences, in the nasopharyngeal structure, when they reported in their study that the cephalometric measurements revealed that the West Indian children have a wider nasopharynx than the whites.

It appears that different racial groups have different airway dimensions which can also be different in its response to the treatment.

### **2.7.3 The relationship between the age and the airway**

Linder-aronsen and Leighton (1983) carried out a study to examine the development of posterior nasopharyngeal wall between the age of 3 and 16 years. They found that the size of the soft tissue was greater at age of 5 years, which means a more restriction of the airway spaces. Also, they found a decrease in the pharyngeal soft tissue from age 6-10 years.

Taylor *et al.* (1996) in a longitudinal study on 16 male and 16 female subjects to find out the effects of growth on bony and soft tissue structures of the oropharynx. They

concluded that a greater rate of changes in the soft tissue measurements of the posterior pharyngeal wall occurred between 6 to 9 years and 12 to 15 years, and that growth increments were very small between 9 and 12 years.

#### **2.7.4 Airway and head position**

Ingman *et al.* (2004) designed a study to examine the differences in airway dimensions, in two different head positions, in patients suffering from air way resistance syndrome or obstructive sleep apnea. The first was the upright and the second was the supine position. The results showed that there was no significant difference between the two positions in the nasopharyngeal or retro pharyngeal area. However, the oropharyngeal area showed a significant narrowing in the supine position, that the distance between the soft palate and the posterior pharyngeal wall was reduced significantly. Also, they found that the thickness of the soft palate increased in supine position compared with the upright position but the length was not affected. Alteration in the tongue form also had been detected in the two different positions, in length and thickness; it became thicker and shorter in the supine position. They suggested that the changes in the soft palate and the tongue are the reasons behind the changes in the oropharyngeal dimensions between the two different positions.

#### **2.7.5 Hyoid bone position and airway dimension**

Hyoid bone position is of a great clinical interest because it plays an important role in maintaining the upper airway dimensions. (Bibby and Preston, 1981)

In Class II subjects, hyoid bone was located in an upward and backward position (the

Hyoid bone was closer to the mandible vertically and to C3 horizontally compared with Class I). Whereas, In Class III subjects the hyoid bone was more anteriorly positioned compared with Class I (Abu Allhaija and Al-Khateeb, 2005).

During mandiblar set back, a change in the position of the hyoid bone to a more posteroinferior position was reported and found to result in narrowing of the hypopharyngeal air ways (Athanasίου et al., 1991; Enacar *et al.*, 1994; Kawamata *et al.*, 2000). While during mandibular advancement, an initial forward movement of the hyoid bone was observed, but after the first year, hyoid bone returned to its pre operative position (Eggensperger *et al.*, 2005).

## **2.7.6 Methods of measuring the airway dimension**

### ***1. Lateral head film and cone-beam computed tomography scan:***

The main disadvantage of the lateral head film for assessment of the airway dimensions is the inability to quantify the transverse dimension, as evident in the frontal plane, since it is a 2-D projection of 3-D structure. Also, there is a lot of superimposition of lateral structures on the head film, so some landmarks are difficult to be identified accurately. A lateral head film often outlines the contours of bony objects that are not anatomically related. (Holmberg and Linder-Aronson, 1979)

A study was done by Aboudara *et al.* (2009) to compare nasopharyngeal airway size between a lateral cephalometric head film and a 3-dimensional cone-beam computed tomography scan in adolescent subjects. The results revealed that cephalometric head film provided a good general overall indicator for nasopharyngeal airway patency especially in the portion of the airway with sever restriction. Also there was a significant positive



relationship between nasopharyngeal airway size on a lateral head film and its true volumetric size on a CBCT scan. The subject with the smallest airway area viewed on the lateral cephalometric head film had the smallest corresponding airway volume; thus, the head film can provide valuable information about airway size. On the other hand there was considerable volume variability between subjects with similar airway area, thus, accurate determination of airway volume from the lateral head film is difficult and questionable because there could be a small volume that is not detected.

The position of the patient while taking the radiograph was one of the main limitations in Aboudara *et al.* (2009) study to hold a comparison. The CBCT scans were taken in the supine position, whereas lateral head films were taken in an upright position. This difference in position was solved by evaluating only the nasopharynx.

Previous studies by other investigators indicated that head position can modify the airway space in retro palatal area. (Yildirim *et al.*, 1991; Battaegl *et al.*, 2002)

## **2. *Quantitative computed tomography***

The major advantages of computed tomography are that it is the only readily accessible, relatively noninvasive imaging modality that allows airway wall and lumen dimensions to be measured in vivo (de Jong *et al.*, 2005)

Quantitative computed tomography has already led to an improved understanding of variations in airway dimensions in normal individuals, and to a better understanding of the airway changes that occur in many pulmonary diseases.

### ***3. Hyperpolarised gas magnetic resonance imaging (MRI) techniques***

In this technique, three dimensional reconstruction of the airway lumen can be performed. However, the use of this technique will remain limited as a research tool, because the airway wall thickness cannot be quantified, and the limited availability of a hyperpolarised helium or xenon 129 source makes the widespread use of this method problematic (Tooker *et al.*, 2003).

### ***4. Optical Coherence Tomography***

Optical coherence tomography is a new micron scale resolution optical imaging method used in studies of the eye, gastrointestinal tract, and bronchial lesions.

Optical coherence tomography is a promising new micron scale resolution imaging technique that can image small airway of 2 mm in diameter or less. This suggests that it is a more sensitive tool in detecting airway wall remodeling, which raises the possibility that Optical coherence tomography could be used to study airway changes in vivo in patients with chronic obstructive pulmonary disease and assess therapeutic potential of novel airway therapies. (Coxson *et al.*, 2008)

### ***5. Rhinomanometry and acoustic rhinometry***

These are objective tests for the assessment of nasal airway patency. Rhinomanometry measures air pressure and the rate of airflow during breathing, which are both used to calculate nasal airway resistance and pressure flow relationships during the respiratory cycle. Acoustic rhinometry uses a reflected sound signal to measure the cross-sectional area and volume of nasal passage. Acoustic rhinometry gives an anatomic description of a nasal passage, (Clement and Gordts, 2005)

### **2.7.7 Airway dimensions and bimaxillary proclination**

Bhatia (1979) found some association between the nasopharyngeal depth and measurement of dentoalveolar prognathism.

Watson *et al.* (1968) found no correlation between nasal respiratory resistance and jaw prognathism.

Jones and Bahatia (1994) designed a study to examine the relationship between the naso respiratory structure and function and dento facial structure in different racial backgrounds and used lateral cephalograms for that. The study was carried out in the king's college school of medicine and dentistry, in which a high number of West Indian patients was treated for the bimaxillary proclination. This was helpful to study the relationship between the nasopharyngeal structure and function in West Indian patients, who have bimaxillary proclination and compare them with that of British white patients. The results showed that most of the West Indians had more prognathic jaws depending on the SNA, SNB measurements, and more procumbent incisors. The nasopharyngeal measurements showed that the West Indians had a wider bony nasopharynx (PNS-BA) than whites, a deeper nasopharynx with wider (PNS-HOR-BA) angle. The differences in the bony measurements were also reflected on the soft tissue measurements; the mean values for adenoids thickness (PNS-AD1, PNS-AD2) were higher in West Indians, but that was not statistically significant. The values of naso respiratory function in terms of nasal respiratory resistance were measured by the rhinomanometry and showed that the West Indians with bimaxillary proclination had lower values for both the anterior and posterior rhinomanometry. There was a significant negative relationship between the width of the nasopharynx and the nasal respiratory resistance, which means that the wider the naso pharynx, the reduced nasal respiratory resistance. However, they suggested that this relation may not be strong, because of the following: the correlation was low, there

were other factors above the nasopharynx influencing the nasal respiratory resistance, and the airway dimension is a 3 dimensional structure, not a 2 dimensional as seen on the radiograph.

### **2.7.8 Airway dimensions and other dentofacial morphology**

Adenoids have long been regarded as one of the chief causes of mouth breathing. It is accompanied by a description of a particular facial expression, said to be typical of individuals with adenoids and mouth breathing, i.e. the adenoid faces. In these cases the mouth stays open, the nose appears flattened, the nostrils look small and underdeveloped, the upper lip short, the lower lip thick and everted. The dentition is stated to be of a special type, consisting of protruding upper incisors, a narrow V-shaped upper jaw with a high palatal vault, and a class II relation between the upper and lower jaws. (Brash, 1929; Negus 1955)

A study was done by Field *et al.* (1991) to compare the relationship between the facial height and the percentage of mouth breathing. The results suggested that the relationship is not nearly as clear-cut as theory might predict, which revealed that both normal and long face children are likely to be predominantly nasal breathers under laboratory conditions. A minority of the long-face children had less than 40 *per cent* nasal breathing, while none of the normal children had such low nasal percentages. The majority of both normal and long face children are not mouth breathers.

These results was in agreement with Linder-Aronson (1970) who stated that there is a controversy about the effect of respiration and the development of malocclusion, and he suggested that total nasal obstruction is mostly the underlying factor in alteration of the pattern of growth and leading to malocclusion in experimental animals and humans.

On the other hand, the majority of the long-face individuals has no evidence of nasal obstruction and must have some other etiologic factor as the principal cause of their malocclusion. Partial nasal obstruction resulted from alterations in posture and a slight increase in the percentage of oral respiration is not great enough to create a severe malocclusion. Mouth breathing, in short, may contribute to the development of orthodontic problems but is difficult to indict as a frequent etiologic agent.

Trask *et al.* (1987) conducted a study on Swedish children who underwent adenoidectomy. They showed that children in the adenoidectomy group had a significantly greater tendency toward maxillary constriction and more upright incisors. They also had a longer anterior face height than control children.

Freitas *et al.* (2006) looked at the upper and lower pharyngeal widths and vertical growth patterns in patients with untreated Class I and Class II malocclusions and also in normal individuals. They used McNamara's airway analysis of the lateral cephalograms and showed that the nasopharynx was narrower in patients with vertical growth pattern than in the normal group for both Class I and Class II malocclusions. They suggested that significant relationships between upper airway dimensions and type of malocclusion do exist, with narrower nasopharyngeal dimensions in subjects with Class II malocclusion.

This is in contrast to McNamara's results, which showed no significant association between upper airway spaces and type of malocclusion. (McNamara, 1981)

These contradicting results might have been affected by the differences in the way the sample was selected. In McNamara's study, sample consisted of only healthy patients without obvious pharyngeal pathology, whereas Freitas *et al.* (2006) used randomly selected subjects.

Another study looked at the relationship between maxillary arch widths and snoring found out that children snoring regularly at age 4 had reduced maxillary arch width compared to those not snoring. This reduction in maxillary arch width is retained throughout childhood regardless of adenotonsillar surgery, and even in the cases where snoring was reduced. The study supported that genetics is the basis for growth and development (Löfstrand-Tideström and Hultcrantz, 2010)

This was in disagreement with another study which reported a strong tendency for normalization of maxillary growth after adenotonsillar surgery especially at younger ages (Hultcrantz *et al.*, 1991)

Children with genetically constricted upper arch had an increased risk of snoring and sleep disordered breathing. Their maxillary width development had changed very little by adenotonsillar surgery, even in the cases where snoring is cured. Therefore, cases in which snoring persists or relapses, after surgery, should be considered for other treatment modalities; such as orthodontic maxillary expansion and/or functional training. Collaboration between otorhinolaryngologist and orthodontist is necessary (Löfstrand-Tideström and Hultcrantz, 2010).

Despite the fact, that is on an epidemiological level, that mouth breathers have a higher prevalence of class II malocclusion, anterior open bite and posterior crossbite than general population, heredity plays a more important role in facial growth and development (Löfstrand-Tideström *et al.*, 1999).

No one can predict with any certainty whether or not a mouth breathing child will develop a malocclusion. However, it is clear that mouth breathing is capable of adding an environmental weight to the etiology of such malocclusions. The triad of class II malocclusion, anterior open bite and posterior crossbite is not the most prevalent inter-arch relationship among the studied nasal impaired children, and although this triad seems

to be increased in a mouth breather sample than in the general population, a significant number of mouth breathing children showed a normal occlusion (Souki *et al.*, 2009).

Based on the orthodontic point of view, ENT doctors should consider treating all mouth breather children, regardless of the etiological factor, since it is not possible to identify the risk of developing malocclusion based solely on routinely used criteria (Souki *et al.*, 2009)

### **2.7.9 Orthodontic treatment and airway dimension**

#### ***1. Effects of Rapid Maxillary Expansion (RME) on airway dimensions:***

Timms (1987) investigated the relationship between posterior crossbite and respiratory diseases and found that subjects with posterior crossbite had three times more diseases, such as upper respiratory tract infection, allergic rhinitis and asthma, than the patients without posterior crossbite. He summarized the advantages of using RME in patients with respiratory impairment as the following:

- Widening of nasal airway, decreasing the airway resistance and so improving natural physiological function which intern reduces respiratory diseases and morbidity.
- This non surgical widening (RME) prevents scar tissue formation, destruction of intranasal morphology, and loss of erectile tissue.
- RME can also be applied in early time periods when surgery is inadvisable.

Gray (1975) investigated the medical results of RME on 310 cases, and found that approximately half of the cases could be protected from cold, respiratory infections, nasal

allergy, and many cases of asthma. And over 80 *per cent* of the cases changed their breathing pattern from mouth to nose.

Buccheri *et al.* (2004) investigated pharyngeal airway changes after RME, and found that RME caused an increase in pharyngeal lumen and an improvement in nasal breathing.

Palaisa *et al.* (2007) used CT scanning to measure the area and volume of nasal cavity in 19 subjects who underwent RME treatment. The results revealed a significant increase in anterior nasal cavity area of about (13.5 *per cent*). Nasal volume of middle and posterior nasal cavity also increased significantly of about 10 *per cent* and 15 *per cent* during post-expansion and post-retention. These changes were mainly stable at different retention periods.

On the other hand, Enoki *et al.* (2006) reported non significant changes in the nasal airway volume after treatment with RME. However, they found a significant decrease in nasal airway resistance.

## ***2. Effects of RME on Obstructive Sleep Apnea (OSA)***

Cessations of breathing for ten seconds or longer are called (apnea), when thirty or more apneic episodes occur in course of seven hours of sleep, resulting in excessive sleepiness during the waking hours, then the person is described as having sleep apnea syndrome. (Cote, 1988)



Obstructive sleep apnea syndrome (OSAS) is caused by recurrent upper airway obstruction during sleep, and it manifests as loud snoring, arterial oxygen desaturation, sleep fragmentation, and excessive daytime sleepiness (Block *et al.*, 1979).

OSA affects 1-10 *per cent* of the subjects (Owen *et al.*, 1995; Ferreira *et al.*, 2000).

RME may be used as a contributory treatment alternative in mild-to-moderate OSA cases, where maxillary constriction is present. (Seto *et al.*, 2001)

Cistulli *et al.* (1998) showed that RME was an effective treatment in 90 *per cent* of young patients having mild to moderate OSA and maxillary constriction. The mechanism for the resolution of OSA following RME related to improved nasal airflow, which results in the generation of lower subatmospheric inspiratory pressures and hence reduces the vulnerability to pharyngeal collapse.

This was in agreement with Villa *et al.* (2007) who suggested that RME was an effective treatment approach for treating children with OSA. They suggested that its effect may be related to increased pharyngeal dimensions, new tongue position, changing of anatomical structures, improved nasal airflow, significant improvements of nasopharyngeal functions, and reduced nasorespiratory problems.

### ***3. Effect of maxillary protraction on airway dimensions***

Okuyay and Ulukaya (2008) found that the desirable effect of face masks on both jaws in patient with class III malocclusion was by stimulating the forward growth of the maxilla and moving the maxillary teeth forward, while the reciprocal forces acting on the mandible caused a clockwise rotational effect. A significant increase in area was observed in the upper part of the airway spaces, especially at the nasopharynx. So, maxillary

protraction without rapid maxillary expansion in patients with retrusive maxilla caused the upper airway dimensions to increase. This was in agreement with Hiyama *et al.* (2005) who explained that the increase in the airway dimensions after using maxillary protraction appliances was due to clockwise rotation of the mandible which might also altered the tongue position. Another explanation behind the increased upper airway dimensions might be due to anterior displacement of PNS, which could have resulted in a forward movement of the soft palate.

On the contrary, Mucedrero *et al.* (2009) found no association between the sagittal airway dimensions and using face mask therapy in patients with class III malocclusion either with rapid maxillary expander or without.

#### **4. Orthognathic surgery and air ways dimensions**

Orthognathic surgery, involving movement of the jaws and other facial skeleton, will result in positional changes of the structures directly attached to the bone and changes in the tension of the attached soft tissues and muscles.

Soft tissues and associated muscles including soft palate, tongue and hyoid muscles are attached directly or indirectly to the maxilla and the mandible. So, any alteration of these soft tissues will be reflected on the posterior airway spaces.

It has been found that there was strong associations between the posterior airway spaces and respiratory disturbances in patients with posterior airway spaces of less than 5 mm (at base of tongue level), and a mandibular plane-to-hyoid distance of greater than 24 mm. Those patients had the highest respiratory disturbance index (RDI). (Partinen *et al.*, 1988)

### ***Mandibular Setback***

It has been reported that during mandibular set back, the position of the hyoid bone will be changed to a more posteroinferior position. This will result in narrowing of the hypopharyngeal airway dimensions and displacement of the tongue to the same direction (Kawamata *et al.*, 2000). The posteriorly displaced tongue in turn narrows the retrolingual spaces and decreases the posterior airway dimensions (Athanasίου *et al.*, 1991; Enacar *et al.*, 1994; Kawamata *et al.*, 2000;)

### ***Mandibular advancement***

Turnbull and Battagel (2000) reported an increase in the retropalatal and retrolingual dimensions of the airway significantly after mandibular advancement.

Many studies supported the use of mandibular advancement for the treatment of obstructive sleep apnea (Powell *et al.*, 1983; Kuo *et al.*, 1979). However, a study carried out by Eggersperger *et al.* (2005), with the longest follow-up period of 12 years after mandibular advancement, showed that mandibular advancement surgery alone possibly did not achieve a stable increase in the pharyngeal airway dimensions over a long-term period of 12 years. There was a significant decrease in upper and middle pharyngeal airway spaces, which ended up with measurements lesser than their preoperative values. However, lower pharyngeal airway size had returned to its preoperative value.

The long-term benefits of single mandibular advancement to increase the airway size are questionable, and can be affected by a number of other factors.

Eggersperger *et al.* (2005) found that an initial forward movement of the hyoid bone was observed, but after the first year, hyoid bone returned back to its preoperative position and

at the end of the observation period, the position of hyoid bone was more posterior than it had been preoperatively.

### ***Surgical expansion***

In patients having constricted jaw and obstructive sleep apnea, transverse expansion of the jaw via orthognathic surgery or distraction osteogenesis is beneficial for the treatment of obstructive sleep apnea (Conley and Legan, 2006).

Obstructive sleep apnea can be as a result of the posterior displacement of the tongue when there is jaw constriction. Therefore, transverse expansion will create more spaces for the tongue and oral tissues anteriorly and prevent their displacement posteriorly. Another suggested reason is that the expansion of the maxilla may widen the nasal cavities and decrease the nasal resistance. (Conley and Legan, 2006)

However, this is in contrast to another study in which the authors found that the expansion did not cause a significant widening of the airway over the long term (Malkoç *et al.*, 2007).

### ***5. Effect of extraction - non extraction on airway dimensions:***

Valiathan *et al.* (2010) examined the effects of extraction and non extraction treatments on oropharyngeal airway volume using CBCT. They found that no statistically significant oropharyngeal airway volume changes between cases the four premolar extraction group and non extraction group.

On the other hand, Germec-Cakan *et al.* (2010) found that the middle and inferior airway size were reduced in the group treated with extraction and maximum anchorage, while in the group treated with extraction and minimum anchorage the superior and middle airway

size increased significantly. However, in patients treated without extraction, by air-rotor stripping, no significant changes were observed in airway dimensions.

#### ***6. Effect of functional orthopedic treatment of skeletal class II on airway dimensions***

Ozbek (1998) carried out a study to examine the effect of Harvold functional activator on the oropharyngeal dimensions. He found that class II subjects treated with functional appliance showed a significant increase in the oropharyngeal airway dimension compared with untreated subjects.

## **CHAPTER THREE: - AIMS AND NULL HYPOTHESIS**

### **3.1 Aims of the study:**

- 1) To report on upper airway dimensions in patients with bimaxillary proclination.
- 2) To investigate the effect of orthodontic treatment with first premolar teeth extraction in bimaxillary proclination cases on the upper airway dimensions.
- 3) To find out the upper and lower arch dimensional changes associated with first premolar extraction in the treatment of bimaxillary proclination.
- 4) To study the relationship between upper and lower arch dimensional changes and the changes in upper airway dimension.

### **3.2 Null hypothesis**

- Treatment of bimaxillary proclination by extraction of upper premolar teeth has no effect on the upper airway dimensions.
- Upper and lower arch dimensional changes have no effect on the upper airway dimensions.

## **CHAPTER FOUR: - MATERIALS AND METHODS**

### **4.1 Study design:**

This was a retrospective study carried out on the available pre and post orthodontic treatment records of patients who had bimaxillary proclination and were treated at Dental Teaching centre of Jordan University of Science and Technology (JUST) and other private practices in Amman. An ethical approval for conduction of this study was obtained from the Institution of Research Board (IRB) at Jordan University of Science and Technology (Appendix A).

### **4.2 Subjects and selection criteria:**

This study consisted of 70 bimaxillary proclination patients (51 females, 19 males). Patients were divided into two groups according to the treatment plan; extraction or non extraction. The first group was the extraction group and consisted of 31 patients who had orthodontic treatment with extraction of four first premolar teeth. The second group was the non extraction group and consisted of 39 patients treated orthodontically without extraction. All the patients included in this study were selected according to the following criteria:

- 1) Patients had bimaxillary proclination with ( $UI/Max \geq 115^\circ$ ) and ( $LI/Mand \geq 99^\circ$ ).

( Keating, 1985)

2) No medical history, Patients with medical history of pharyngeal pathology and/or nasal obstruction, snoring, obstructive sleep apnea, adenoidectomy, and tonsillectomy were excluded.

3) Patient's age  $\geq 18$  years.

4) Patients had good pre and post orthodontic treatment lateral cephalograms and dental casts.

5) Patients had no severe crowding or severe spacing.

6) Patients had been treated by fixed orthodontic appliances only; no arch expansion or orthognathic surgery was planned in the treatment.

Subjects were treated by specialist orthodontists and had full records of pre and post treatment lateral cephalograms and dental casts.

These records were obtained from the department of orthodontics in the dental teaching center of Jordan University of Science and Technology (JUST) and three private clinics in Amman.

The treatment plan for each patient and the need for extraction had been decided by the specialist orthodontist who treated the patient. Orthodontic treatment was carried out using upper and lower fixed pre-adjusted edgewise orthodontic appliances "0.022  $\times$  0.028".



### **4.3 Study groups**

Subjects were divided into 2 groups according to the treatment plan (extraction or non extraction). The first group was the extraction group and consisted of 31 patients (23 females, 8 males). Age of the patients in this group ranged between 18 and 23 years with an average age of  $19.21 \pm 1.46$  years. Patients in this group received orthodontic treatment with extraction of four 1<sup>st</sup> premolars. The second group was the non extraction group and included 39 patients (28 female and 11 males) who had orthodontic treatment without extraction. Age of this group again ranged between 18 and 23 years. With an average age was  $19.93 \pm 1.73$  years.

### **4.4 Record analysis:**

Pre and post orthodontic lateral cephalograms and dental casts were analyzed by the same investigator (N Al S).

#### **4.4.1 Cephalometric records**

Pre and post treatment lateral cephalograms for each participant were taken with cephalostate under a standardized technique with the teeth in maximum intercuspation. All the cephalograms were hand traced by one investigator (N Al S) on acetate tracing paper carefully attached to the radiographs. During tracing, the room was darkened and the viewing screen was blanked off showing only the radiograph.

Magnification of each radiograph was corrected according to the magnification factor specific for that cephalostate taken by; to make the magnification standardized for all the entire radiographs used in this study.

Thirty one land marks (21 landmarks for sagittal airway measurements, and 10 for skeletal and dental measurements) had been identified for each cephalogram yielding 24 linear and 7 angular measurements (Figure 4.1).

Definition of the different landmarks and measurements are shown in Table 4.1-3.

The measurements were performed manually using a ruler to the nearest 0.1mm and protractor to the nearest 0.5°.

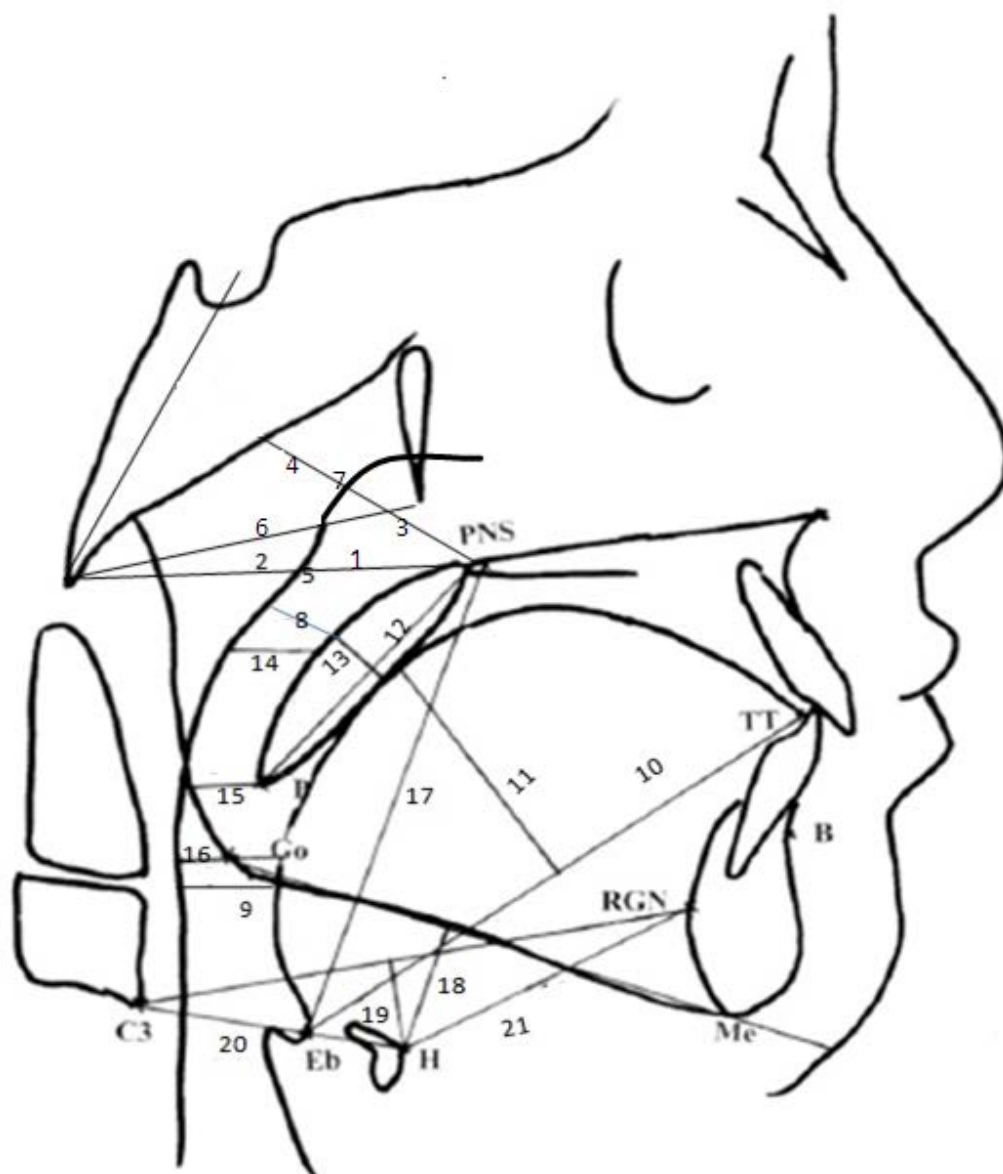
#### 4.4.1.1 Cephalometric measurements of the skeletal and dental relationships:

Analysis of the skeletal and dentoalveolar measurements included the following measurements presented in table (4.1).

**Table 4.1:** Definition of the skeletal and dentoalveolar measurements used in this study

Measurement	Definition
SNA	Angle formed by intersection of Sella-Nasion and Nasion-A point.
SNB	Angle formed by intersection of Sella-Nasion and Nasion-B point.
ANB	Angle formed by intersection of Nasion-B point and Nasion-A point.
MMP angle	Angle formed by intersection of Maxillary and mandibular planes.
UI-Maxilla	Angle formed by intersection of long axis of the most prominent maxillary incisor and Maxillary plane.
LI-Mandible	Angle formed by intersection of long axis of the most prominent mandibular incisors and mandibular plane.
Interincisal angle	Angle formed by the intersection of the most prominent upper incisor axis and the most prominent lower incisor axis.
ANS-PNS	Linear distance between ANS and PNS.
Wits	Linear difference of a perpendicular line from A point to the functional occlusal plane and a perpendicular line from B point to the functional occlusal plane
LI/A-Pog	Linear distance between the most prominent lower incisor and a line connecting A point to Pogonion.

#### 4.4.1.2 Cephalometric measurements of the airway



**Figure 4.1:** Cephalometric measurements of the airway and soft tissue

(McNamara, 1984; Abu Allhaija and Al-Khateeb, 2005; Martin *et al.*, 2006)

Analysis of the airway dimension included the following landmarks presented in table (4.2) as shown on figure 4.1:

**Table 4.2:** Landmarks used for analysis of airway dimensions.

Landmark	Definition
TT	Tongue tip
Eb	Base of epiglottis
P	Tip of soft palate
PNS	Posterior nasal spine
Me	Menton
Go	Gonion
B	Point B
RGN (retrognathion)	The most posterior point of symphysis
H (hyoidale)	The most superior and anterior point on the body of the hyoid bone
C3	Anteroinferior limit of third cervical vertebra

Analysis of the airway dimension included the following measurements presented in table (4.3) as shown on figure 4.1.

**Table 4.3:** Airway dimension measurements.

1	PNS-AD1	Lower airway thickness; distance between PNS and the nearest adenoid tissue measured through the PNS-Ba line (AD1).
2	AD1-Ba	Lower adenoid thickness; defined as the soft-tissue thickness at the posterior nasopharynx wall through the PNS-Ba line.
3	PNS-AD2	Upper airway thickness; distance between PNS and the nearest adenoid tissue measured through a perpendicular line to S-Ba from PNS (AD2).
4	AD2-H	Upper adenoid thickness; defined as the soft-tissue thickness at the posterior nasopharynx wall through the PNS-H line (H, hormion, point located at the intersection between the perpendicular line to S-Ba from PNS and the cranial base).
5	PNS-Ba	Total lower sagittal depth of the bony nasopharynx.
6	Ptm-Ba	Posterior sagittal depth of the bony nasopharynx.
7	PNS-H	Total upper airway thickness.
8	McNamara's upper pharynx dimension	Minimum distance between the upper soft palate and the nearest point on the posterior pharynx wall.
9	McNamara's lower pharynx dimension	Minimum distance between the point, where the posterior tongue contour crosses the mandible, and the nearest point on the posterior pharynx wall.

10	TGL	Tongue length (Eb-TT).
11	TGH	Tongue height (maximum height of tongue along perpendicular line of Eb-TT line to tongue dorsum).
12	PNSP	Soft palate length (PNS-P).
13	MPT	Soft palate thickness (maximum thickness of soft palate measured on line perpendicular to PNS-P line).
14	SPAS	Superior posterior airway space (width of airway behind soft palate along parallel line to Go-B line).
15	MAS:	Middle airway space (width of airway along parallel line to Go-B line through P).
16	IAS	Inferior airway space (width of airway space along Go-B line).
17	VAL	Vertical airway length (distance between PNS and Eb).
18	MPH	Perpendicular distance from hyoid bone to mandibular plane.
19	HH1	Perpendicular distance from hyoid bone to the line connecting C3 and RGN.
20	C3H	Distance between hyoid and C3.
21	HRGN	Distance between hyoid bone and RGN.

#### **4.4.2 Dental Cast analysis:**

Pre and post orthodontic treatment dental casts (upper and lower) were analyzed manually by the same investigator (N Al S). All the measurements were performed using a divider and an orthodontic ruler to the nearest 0.1 mm.

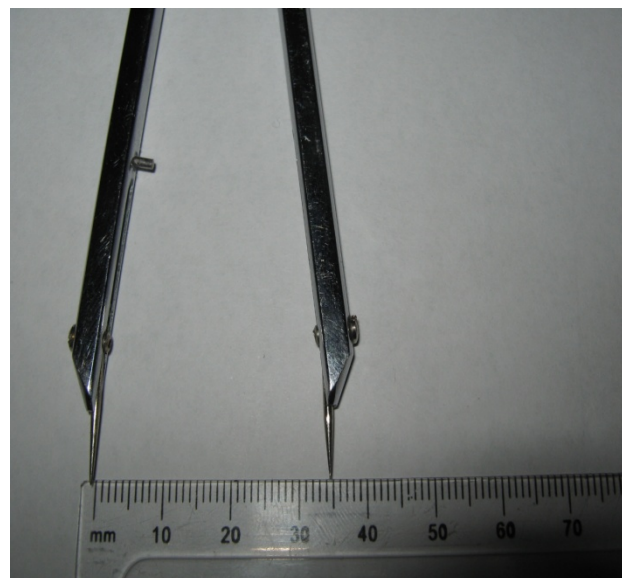
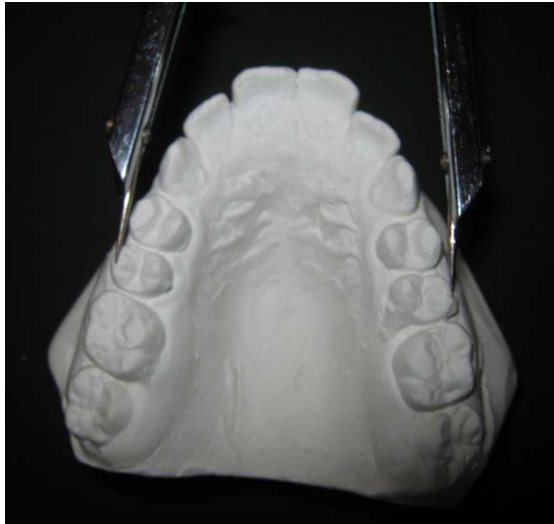
The following measurements were obtained from each dental cast:

- Inter canine width: the measured distance between the cusp tips of both canines (figure 4.2).
- Inter premolar width: the measured distance from the buccal cusp of a premolar on one side to the buccal cusp of the contra lateral premolar ( figure 4.3)
- Inter molar width: the measured distance from the mesio-buccal cusp tip of a first molar on one side to the mesio-buccal cusp tip of the contra lateral first molar (figure 4.4)
- Arch length: the distance from the tip of mesio buccal cusp of first molar on one side to the mesio buccal cusp of first molar on the contra lateral side. A piece of wire was adapted between the mesio buccal cusp of first molars to the tip of buccal cusp of premolars , canines, and the incisor edges on both sides, then the wire was straightened and measured on a ruler as reported by Proffit (2000). ( figure 4.5)

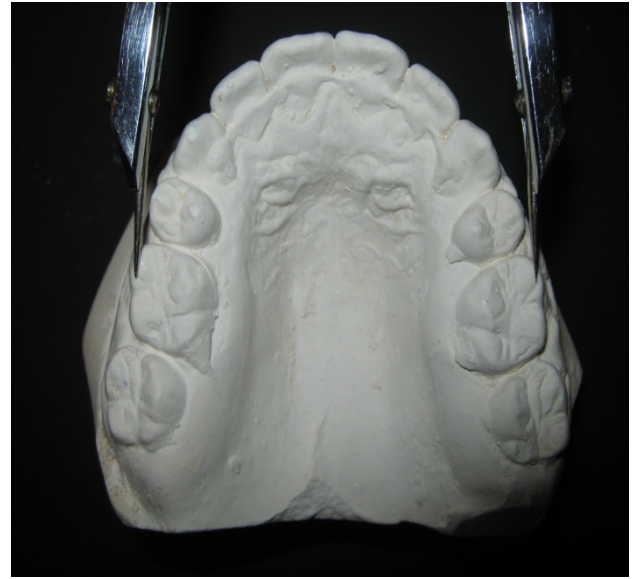




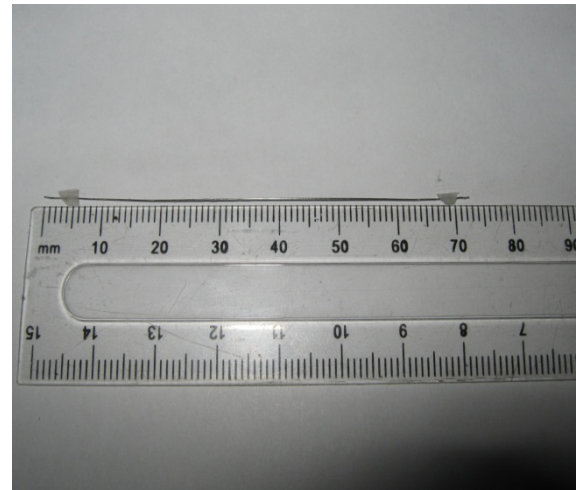
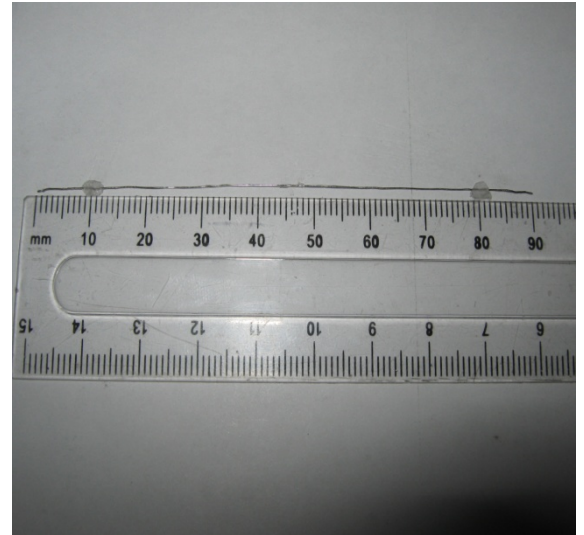
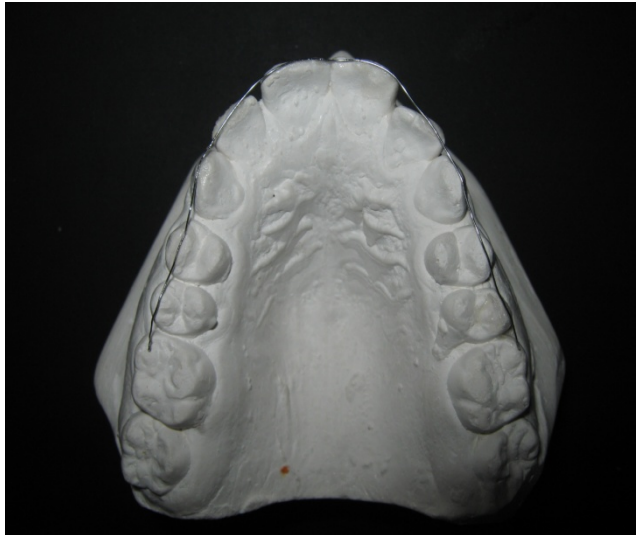
**Figure 4.2:** pre and post treatment inter canine width



**Figure 4.3:** pre and post treatment inter premolar width



**Figure 4.4:** pre - post treatment inter molar width



**Figure 4.5:** pre and post treatment arch length

#### **4.4.3 Error of the Method:**

Fourteen lateral cephalograms (10 percent of total sample) and 14 pairs of dental casts were randomly selected and re analyzed after one month interval. Dahlberg's formula (1940) was used to calculate the standard error of the method.

Table (4.4) shows the Dahlberg's error for the double measurements of all variables used in this study. Dahlberg's error ranged from 0.062mm for MAS to 0.192mm for arch length.

#### **4.4.4 Statistical analysis:**

Statistical analysis was performed using the Statistical Package for Social Science (SPSS) computer software (SPSS 17.0, SPSS Inc., Chicago, USA).

Descriptive statistics (means and standard deviation) were calculated for all the measured variables. Paired t-test was conducted to detect the differences between pre and post treatment measured variables for the same individuals. Significance was pre-determined at 0.05 level.

**Table 4.4:** Dahlberg's Measurement error

Parameter	Dahlberg's value	Parameter	Dahlberg's value
<b>Cephalometric</b>		<b>Cephalometric</b>	
<b>Airway and soft tissue</b>		<b>Skeletal and Dentoalveolar</b>	
PNS-AD1 (mm)	0.113	SNA	0.171
AD1-Ba	0.107	SNB	0.156
PNS-AD2	0.107	ANB	0.189
AD2-H	0.094	MMP angle	0.124
PNS-Ba	0.133	UI-Maxilla	0.156
Ptm-Ba	0.113	LI-Mandible	0.124
PNS-H	0.094	Interincisal angle	0.156
McNamara's upper	0.113	ANS-PNS	0.107
McNamara's lower	0.071	Wits	0.080
TGL	0.118	A-Pog	0.087
TGH	0.080	<b>Casts measurements</b>	
PNSP	0.182	<b>Upper arch</b>	
MPT	0.071	arch length	0.192
SPAS	0.107	inter canine width	0.087
MAS	0.062	inter 1st premolar	0.094
IAS	0.094	inter 2nd premolar	0.080
VAL	0.147	inter molar	0.124
MPH	0.101	<b>Lower arch</b>	
HH1	0.094	arch length	0.171
C3H	0.113	inter canine width	0.087
HRGN	0.094	inter 1st premolar	0.062
		inter 2nd premolar	0.094
		inter molar	0.080

## **CHAPTER FIVE: - RESULTS**

### **5.1. Premolar extraction group**

Means and standard deviations of pretreatment and post treatment measurements for cephalometric and dental cast measurements in extraction group are shown in tables 5.1-3.

#### **5.1.1 Cephalometric measurements**

##### **5.1.1.1 Dental and skeletal relationships**

The Upper incisors to maxillary plane angle showed a highly statistically significant change ( $P=0.000$ ) during treatment with a mean reduction of  $10.26^\circ$ . Also lower incisor to mandibular plane angle, inter-incisal angle, and lower incisor to A-Pog line showed a highly statistically significant change ( $P=0.000$ ).

Skeletally, none of the measured variables were statistically significant.

**Table 5.1:** Means and standard deviations of pretreatment and post treatment measurements for dental and skeletal relationships of extraction group

Measurement	Pre treatment Means (SD)	Post treatment Means (SD)	Mean difference	Significance P - value
<b>SNA (°)</b>	82.61 (3.35)	82.52 (3.26)	-0.09	0.717
<b>SNB (°)</b>	79.35 (2.61)	78.97 (2.83)	-0.38	0.103
<b>ANB (°)</b>	3.55 (2.06)	3.52 (2.36)	-0.03	0.877
<b>MMPA (°)</b>	28.19 (4.88)	28.29 (4.49)	0.10	0.834
<b>UI-Max. (°)</b>	122.10 (3.70)	111.84 (6.59)	-10.26	0.000***
<b>LI-Mand. (°)</b>	104.35 (5.33)	94.65 (6.53)	-9.70	0.000***
<b>Inter-incisal angle (°)</b>	106.13 (6.28)	125.03 (8.04)	18.90	0.000***
<b>ANS-PNS (mm)</b>	54.76 (3.42)	55.06 (3.09)	0.3	0.336
<b>Wits (mm)</b>	-0.24 (2.49)	-0.16 (2.23)	0.08	0.761
<b>LI/A-Pog (mm)</b>	6.50 (2.20)	3.13 (2.09)	-3.37	0.000***
***P<0.001.				

#### 5.1.1.2 Soft tissues and airway dimensions

The tongue length was reduced as a result of orthodontic treatment with a mean reduction of (1.75mm). This reduction in tongue length was statistically significant (p=0.036).

The mean reduction in the measured upper adenoid thickness (AD2-H) between the pre treatment and the post treatment values was 1.01mm (P=0.023).



**Table 5.2:** Means and standard deviations of pretreatment and post treatment measurements for soft tissues and airway dimensions of extraction group

<b>Measurement</b>	<b>Pre treatment Means (SD) (mm)</b>	<b>Post treatment Means (SD) (mm)</b>	<b>Means difference (mm)</b>	<b>Significance P – value</b>
<b>PNS-AD1</b>	25.39(3.87)	26.00(4.10)	0.61	0.307
<b>ADI –BA</b>	19.84(3.74)	18.58(3.32)	-1.26	0.102
<b>PNS-BA</b>	45.23(3.72)	44.55(3.52)	-0.68	0.083
<b>PNS-AD2</b>	20.77(4.15)	21.48(4.63)	0.71	0.150
<b>AD2-H</b>	11.24(3.19)	10.23(3.66)	-1.01	0.023*
<b>PTM-BA</b>	44.32(3.27)	44.23(3.22)	-.09	0.712
<b>PNS-H</b>	32.02(2.72)	31.45(2.63)	-0.57	0.102
<b>McNamara's upper</b>	9.02(2.42)	9.00(3.21)	-0.02	0.967
<b>McNamara's lower</b>	11.42(3.64)	11.23(4.01)	-0.19	0.717
<b>TGL</b>	73.56(6.09)	71.81(5.86)	-1.75	0.036*
<b>TGH</b>	33.37(4.35)	32.67(3.58)	-0.7	0.263
<b>PNS-P</b>	34.44(3.28)	33.89(4.27)	-0.55	0.470
<b>MPT</b>	5.26(1.583)	5.07 (1.174)	-0.19	0.394
<b>SPAS</b>	11.70 (2.67)	10.93 (2.759)	-1.31	0.079
<b>MAS</b>	9.85 (2.68)	9.04 (3.41)	-0.81	0.072
<b>IAS</b>	11.19 (3.68)	11.30 (3.32)	0.11	0.844
<b>VAL</b>	62.30 (6.01)	61.81 (5.378)	-0.49	0.415
<b>M Plane-H</b>	13.96 (5.55)	12.85 (4.63)	-1.11	0.147
<b>HH</b>	5.63 (5.30)	5.15 (4.85)	-0.48	0.518
<b>C3H</b>	34.22 (4.31)	35.04 (3.75)	0.82	0.202
<b>H RGN</b>	39.85 (6.76)	38.93 (4.86)	-0.92	0.317
*P≤0.05				

### 5.1.2 Dental cast measurements

For the upper arch, statistically significant results were recorded for both arch length and inter canine width ( $P = 0.000, 0.027$ ) respectively. The upper arch length reduced with a mean reduction of 13.77mm whereas inter-canine width increased with a mean increase of (0.94 mm). For the lower arch, highly statistically significant results were recorded for both arch length and inter-molar width ( $P = 0.000$ ). The mean reduction in the lower arch length was (16.52 mm), and in the inter-molar width was (2.25 mm).

**Table 5.3:** Means and standard deviations of pre treatment and post treatment dental cast measurements for the extraction group

Measurement	Pre treatment Means (SD) (mm)	Post treatment Means (SD) (mm)	Means difference (mm)	Significance P – value
Upper arch length	84.58 (6.10)	70.81 (6.01)	-13.77	0.000***
Upper inter-canine width	35.19 (2.30)	36.13 (1.97)	0.94	0.027*
Upper inter-premolar	44.71 (8.29)	44.81 (2.60)	0.10	0.951
Upper inter-molar	50.55 (3.57)	49.58 (2.27)	-0.97	0.74
Lower arch length	71.23 (6.43)	54.68 (15.05)	-16.52	0.000***
Lower inter-canine width	27.97 (2.44)	28.16 (1.57)	0.19	0.604
Lower inter-premolar	38.84 (7.28)	36.29 (1.51)	-2.55	0.056
Lower inter-molar	44.19 (3.09)	41.94 (1.80)	-2.25	0.000***
* $P \leq 0.05$ , *** $P < 0.001$ .				

## **5.2 Non extraction group**

Means and standard deviations of pretreatment and post treatment measurements for cephalometric and dental cast measurements in extraction group are shown in tables 5.4-6.

### **5.2.1 Cephalometric measurements**

#### **5.2.1.1 Dental and skeletal relationships**

In this group, the results have shown that the changes in the upper incisor to maxillary plane angle, lower incisor to mandibular plane angle, and inter incisal angle were not statistically significant ( $P=0.421$ ,  $P=0.269$ ,  $P=0.652$ , respectively).

The only significant results were recorded for SNA and ANB angles. The mean reduction in SNA angle was ( $0.59^\circ$ ) which was a statistically significant change ( $P=0.020$ ).

The same significant change was recorded for ANB angle ( $P=0.013$ ) with a mean reduction of ( $0.51^\circ$ ).

**Table 5.4:** Means and standard deviations of pretreatment and post treatment measurements for dental and skeletal relationships of non extraction group

Measurement	Pre treatment Means (SD)	Post treatment Means (SD)	Mean difference	Significance P - value
<b>SNA (°)</b>	82.41(2.85)	81.82(2.36)	-0.59	0.020*
<b>SNB (°)</b>	79.15(2.86)	78.92(2.65)	-0.23	0.391
<b>ANB (°)</b>	3.28(2.40)	2.77(2.05)	-0.51	0.013*
<b>MMPA (°)</b>	25.47(5.33)	26.03(5.62)	0.56	0.100
<b>UI-Max. (°)</b>	122.08(4.92)	122.79(7.29)	0.71	0.421
<b>LI-Mand. (°)</b>	104.41(4.66)	103.46(5.99)	-0.95	0.269
<b>Inter-incisal angle (°)</b>	108.79(5.83)	108.23(7.73)	-0.56	0.652
<b>ANS-PNS (mm)</b>	56.44(3.64)	56.79(3.61)	0.35	0.231
<b>Wits (mm)</b>	0.24(2.76)	-0.04(2.15)	-0.28	0.367
<b>LI/A-Pog (mm)</b>	3.92(2.18)	4.38(2.25)	0.46	0.124
*P≤0.05.				

#### 5.2.1.2 Soft tissues and airway dimensions

A statistically significant result was recorded for (PNS-BA) (total lower sagittal depth of the bony nasopharynx) with a mean increase of 0.67mm ( $P = 0.038$ ).

Lower airway dimension had statistically significant changes in McNamara's lower and inferior airway space (IAS) ( $P= 0.019$  and  $0.024$ , respectively). McNamara's lower and LAS have reduced by a mean of (1.13 mm, 1.06 mm, respectively).

Vertical airway dimension on the other hand had a statistically significant change only in vertical airway length (VAL) ( $P=0.007$ ) with a mean increase of (2.63 mm).

**Table 5.5:** Means and standard deviations of pre treatment and post treatment measurements for soft tissues and airway dimensions of non extraction group

Measurement	Pre treatment Means (SD) (mm)	Post treatment Means (SD) (mm)	Means difference (mm)	Significance P – value
<b>PNS-AD1</b>	23.95(3.85)	23.62(4.09)	-0.33	0.536
<b>ADI –BA</b>	21.97 (4.35)	22.74(4.48)	0.77	0.113
<b>PNS-BA</b>	45.69(3.66)	46.36(3.34)	0.67	0.038*
<b>PNS-AD2</b>	17.28(3.94)	18.00(4.15)	0.72	0.187
<b>AD2-H</b>	12.62(3.96)	12.59(3.61)	-0.03	0.957
<b>PTM-BA</b>	45.28(3.64)	45.92(3.14)	0.64	0.056
<b>PNS-H</b>	29.90(3.34)	30.59(3.05)	0.69	0.156
<b>McNamara's upper</b>	8.10(2.47)	7.97(2.26)	-0.13	0.706
<b>McNamara's lower</b>	11.64(3.39)	10.51(3.15)	-1.13	0.019*
<b>TGL</b>	74.00 (6.74)	74.80 (7.12)	0.80	0.487
<b>TGH</b>	30.51 (4.18)	31.94 (3.82)	1.43	0.065
<b>PNS-P</b>	33.23 (3.99)	34.26 (3.52)	1.03	0.099
<b>MPT</b>	5.23(1.64)	5.37 (1.30)	0.14	0.595
<b>SPAS</b>	10.63 (3.20)	10.17 (2.17)	-0.46	0.309
<b>MAS</b>	8.86 (2.51)	8.43 (2.58)	-0.43	0.311
<b>IAS</b>	11.97 (3.27)	10.91 (3.23)	-1.06	0.024*
<b>VAL</b>	56.74 (6.19)	59.37 (6.98)	2.63	0.007**
<b>M PLANE-H</b>	14.97 (4.87)	14.57 (5.61)	-0.4	0.686
<b>HH</b>	6.71 (5.02)	7.23 (6.21)	0.52	0.592
<b>C3H</b>	34.66 (5.58)	35.17 (4.43)	0.51	0.593
<b>H RGN</b>	41.80 (5.73)	41.23 (5.95)	-0.57	0.589
*P≤0.05, **P<0.01.				

### 5.2.2 Dental cast measurements

For the upper arch, a highly statistically significant increase was observed in the inter-1<sup>st</sup> premolar and inter-molar width ( $P=0.000$ ) with a mean increase of (3.03 mm, and 1.69 mm, respectively). In addition to that, a statistically significant increase was observed in the inter-canine and inter premolar width ( $P= 0.006$ ,  $P= 0.004$ , respectively). The mean increase was (0.98 mm, and 2.62 mm respectively).

On the other hand, the change in upper arch length was not statistically significant ( $p=0.260$ ) with a mean increase of 1.28 mm.

For the lower arch, the only statistically significant result was recorded for lower inter-second premolar width ( $P=0.015$ ), with a mean increase of 1.02 mm.

All of the other studied variables in the lower arch; arch length, inter-canine, inter-first premolar and inter-molar widths were increased as a result of treatment, but not to a statistically significant level.

**Table 5.6:** Means and standard deviations of pretreatment and post treatment cast measurements for the non extraction group.

<b>Measurement</b>	<b>Pre treatment Means (SD) (mm)</b>	<b>Post treatment Means (SD) (mm)</b>	<b>Means difference (mm)</b>	<b>Significance P – value</b>
<b>Upper arch length</b>	80.28(6.43)	81.56(4.41)	1.28	0.260
<b>Upper inter-canine width</b>	34.10(2.38)	35.08(1.79)	0.98	0.006**
<b>Upper inter-1<sup>st</sup> premolar width</b>	40.92(2.48)	43.95(2.07)	3.03	0.000***
<b>Upper inter-2<sup>nd</sup> premolar width</b>	46.38(5.83)	49.00(2.38)	2.62	0.004**
<b>Upper inter-molar width</b>	50.85(3.44)	52.54(2.67)	1.69	0.000***
<b>Lower arch length</b>	68.92(6.57)	70.41(3.33)	1.49	0.173
<b>Lower inter-canine width</b>	27.26(2.22)	27.36(1.32)	0.1	0.776
<b>Lower inter-1<sup>st</sup> premolar width</b>	35.54(3.32)	36.21(1.65)	0.67	0.228
<b>Lower inter-2<sup>nd</sup> premolar width</b>	41.21(2.71)	42.23(1.96)	1.02	0.015*
<b>Lower inter-molar width</b>	45.77(3.10)	46.05(2.32)	0.28	0.339
*P≤0.05, **P<0.01, ***P<0.001.				

## **CHAPTER SIX: - DISCUSSION AND CONCLUSIONS**

### **6.1. Introduction**

This study was retrospective in nature, aimed to reveal the effect of premolar extraction, and arch dimensional changes on the upper airway dimensions in bimaxillary proclination patients.

Lateral cephalometric radiographs were used in this study to measure the airway dimensions, and dental casts to measure the changes in the arch dimensions.

Using lateral cephalograms to assess the airway dimension has been considered a reliable method (Aboudara *et al.*, 2009)

The effect of extraction and non extraction treatment will be reflected on the arch dimensions as reported in many studies (Sadowsky *et al.*, 1994; Moussa *et al.*, 1995; Elms *et al.*, 1996; Bishara *et al.*, 1997; Kim and Gianelly, 2003; Isik *et al.*, 2005). In this study we examine the arch dimensional changes resulted after the treatment.

Other studies found a relationship between arch expansion and airway dimensional changes (Buccheri *et al.*, 2004; Palaisa *et al.*, 2007). In the present study, the relationship between the extraction, arch dimensions and airway dimensional changes were explored.

The age range was 18-23 years to ensure that the oropharyngeal structures had reached the adult size and no effect from growth would have any effect on the results.



## **6.2 Comparisons with other studies**

### **6.2.1 Premolar Extraction group**

#### **6.2.1.1 Cephalometric results:**

The effect of growth may play a role when evaluating dimensions of the pharyngeal airway dimension. Taylor *et al.* (1996) and Linder-aronsen and Leighton (1983) concluded that a greater rate of changes in the soft tissue measurements of the posterior pharyngeal wall occurred between 6 to 9 years and 12 to 15 years. In this study, the age range was 18-23 years to ensure that the oropharyngeal structures had reached the adult size and no effect from growth would have any effect on the results.

##### **6.2.1.1.1 Dental and skeletal changes**

After four premolar extraction and retraction of the anterior segment, a highly statistically significant reduction was observed in upper incisor to maxillary plane angle, lower incisor to mandibular plane angle, and lower incisor to A-Pog line ( $P=0.000$ ). These results were expected since the aim of treatment was to reduce the incisal inclination and the lip procumbency. Also, these findings were in agreement with other studies (Langberg and Todd, 2004; Germec-Cakan *et al.*, 2010).

For the skeletal measurement, SNA, SNB and ANB angles did not change significantly. This was in agreement with another study (Germec-Cakan *et al.*, 2010) in which they reported that these angles did not change significantly in both minimum and high anchorage extraction cases.

On the contrary, Sharma (2010) reported a significant reduction in the skeletal and soft tissue points A, and B, with mean reduction of  $2.367^\circ$ ,  $1.95^\circ$  in SNA and SNB angles respectively. Such difference in the results may be related to the usage of palatal root torque in the upper and lingual root torque in the lower arch wires during the incisor

retraction, to prevent labial movement of the roots. While in this the incisors inclination has reduced significantly. This indicates that the possible slight labial incisor root movement was responsible for moving A and B points anteriorly and compensating the back ward movement due to incisor retraction.

#### **6.2.1.1.2 Soft tissues and airway dimensions:**

The only significant finding concerning the air ways measurements was for the upper adenoid thickness (AD2-H), in which the mean reduction was 1.01mm ( $p=0.023$ ). Despite this reduction, the airway dimensions weren't affected in any location. This was in agreement with Valiathan *et al.* (2010) who reported that extraction of four premolars with retraction of incisors didn't affect oropharyngeal airway volume.

On the other hand, Germec-Cakan *et al.* (2010) carried out a study to investigate the upper respiratory airway dimensions in non-extraction and extraction subjects treated with minimum or maximum anchorage. They reported that the superior airway space (SPAS) and the middle airway space (MAS) increased significantly in the minimum anchorage group.

On the other hand, the middle airway space (MAS) and the inferior airway space (IAS) were reduced significantly in maximum anchorage group.

They explained this difference between the two groups by a mesial molar movement after resolution of anterior crowding, which was on average 3mm in the minimum anchorage group. This mesial molar movement might have increased the posterior tongue space and accordingly the superior and middle airway dimensions. The other possible cause, they mentioned, was growth. In maximum anchorage group on the other hand, they suggested that after significant incisor retraction, the tongue space might have reduced and resulted in a significant reduction of the MAS and IAS.

In the present study, the anchorage control was not estimated, and the same extraction group might have included both minimum and maximum anchorage cases. This may be the underlying cause why the changes in the airway dimensions, in this study, were not significant.

The other significant finding in our study was the tongue length, which was reduced significantly with a mean reduction of 1.75 mm. This reduction is still in the line of expectations, because the restriction of the tongue after bimaxillary proclination treatment is considered as the main cause of relapse and space reopening. (Proffit, 2000)

Hyoid bone position was also not affected significantly in this group. This was in agreement with that reported by Germec-Cakan *et al.*, (2010) and was expected because it was the only dental movement that was induced in adult patients.

#### **6.2.1.2 Dental cast changes:**

In this study recording changes in arch dimensions is important and need to be recorded when investigating the airway dimensional changes due to extraction or non extraction treatment. Since the effect of extraction and non extraction treatment will be reflected on the arch dimensions as reported in many studies (Sadowsky *et al.*, 1994; Moussa *et al.*, 1995; Elms *et al.*, 1996; Bishara *et al.*, 1997; Kim and Gianelly, 2003; Isik *et al.*, 2005).

Other studies found a relationship between arch expansion and airway changes (Buccheri *et al.*, 2004; Palaisa *et al.*, 2007). So in the present study, the relationship between the extraction, arch dimensions and airway dimensional changes were explored.

Evaluation of arch dimensional changes has not been taken into consideration in the studies investigated the effect of extraction and non extraction on the airway using only x-rays or cone beam C.T, (Valiathan *et al.*, 2010; Germec-Cakan *et al.*, 2010).

Arch width in this study was measured from the buccal cusp tip on one side to the buccal cusp tip on the other side. This was in contrary to Gianelly (2003) who measured the arch widths between the most buccal points on the teeth.

Zachrisson (2001; 2002) stated that measuring arch width from most buccal points on the teeth have disregarded the bucco-lingual inclinations of the related teeth, since if teeth are palatally inclined in a wide alveolar arch, measurements carried out on the most buccal aspects of the teeth will present the dental arch as a wide one, whereas measurements carried out on the cusp tips will reflect the arch as it is during smiling.

So when the crown inclination is taken into consideration it is important to record the measurements between the buccal cusp tips.

In this study, a significant increase in the upper inter canine width was recorded after premolar extraction. This is possibly due to distal movement of the canines to the extraction spaces; into a wider part of the arch. This finding is in agreement with other studies. (Sadowsky *et al.*, 1994; Moussa *et al.*, 1995; Elms *et al.*, 1996; Bishara *et al.*, 1997, Isik *et al.*, 2005).

Neither upper inter-premolar, nor inter-molar width did change significantly in this study. However, inter-molar width was reduced by a mean of 0.97mm, which was in agreement with 0.88 mm reduction reported by Isik *et al.* (2005) and 0.53mm reduction reported by Kim and Gianelly (2003). This reduction may be due to the mesial movement of these teeth towards the narrower anterior part of the arch (Paquette *et al.*, 1992; Luppanapornlarp and Johnston, 1993; Bishara *et al.*, 1997).

In the lower arch, the only significant change in arch width was in the lower inter-molar which was reduced significantly after treatment. This was in agreement with 0.94 mm reduction reported by Kim and Gianelly (2003) and with the findings of Gardner and Chaconnas (1976). The cause behind this reduction may be due to mesial movement of the molar teeth toward the narrower part of the arch.

Lower inter-canine and inter-premolar widths did not change significantly in the present study; this was possibly due to arch customization to reduce the relapses. This is in disagreement with that reported by Isik *et al.* (2005) who reported a significant reduction in the lower inter-second premolar width as a result of mesial movement of the second premolars toward the narrower part of the arch.

Regarding the arch length, our results revealed a significant decrease in both upper and lower arch lengths due to extraction. This was expected because of the extraction of four units and retraction of the incisor was in agreement with Ong and Woods (2001).

## **6.2.2 Non extraction group**

### **6.2.2.1 Cephalometric measurements**

#### **6.2.2.1.1 Dental and skeletal changes:**

In this group, both SNA and ANB angles were reduced significantly after treatment, while the changes in SNB angle did not reach the significant level. This was in disagreement with Germec-Cakan *et al.* (2010) who reported that all the sagittal skeletal measurements in the non extraction group did not change significantly after treatment. This disagreement might be due to the differences in the way of gaining the space to relive the crowding. In Germec-Cakan *et al.* (2010) study, the non extraction group consisted of

13 borderline cases treated without extraction by means of the air-rotor stripping (ARS) for anterior and posterior teeth, also a segmental approach was used to avoid excess protrusion of the incisors. While in our study the main way for gaining the space was by arch expansion especially in the upper arch, this might have resulted in a backward movement of the root apices, and so the A point, resulting in significant reduction in SNA and so ANB angles.

Comparing the vertical skeletal relationship between the two groups in this study, it was about 5.5 folds increase in the non extraction group in which the MMP angle was increased a mean of 0.56 °, while it was 0.10° in the extraction group. In both extraction and non extraction groups, the changes were not significant. This was in agreement with Germec-Cakan *et al.* (2010) who used FMP angle and reported that the change in FMP angle, in the non extraction group, was not significant. MMP angle in the present study was increased, possibly because of arch expansion which caused extrusion of the palatal cusps and down ward rotation of the mandible and also the extrusive nature of the fixed appliance treatment.

Upper and lower incisors inclination did not change significantly after treatment. This was in agreement with Germec-Cakan *et al.* (2010) study, in which the change in upper incisor to SN line and lower incisor to mandibular plane angle was not significant.

#### **6.2.2.1.2 Soft tissues and airway dimensions**

The linear distance (PNS-Ba) which referred to the bony naso-pharynx was increased significantly. This might indicate an anterior displacement of PNS, which could result in a

forward movement of the soft palate and an increase in the superior upper air way dimension.

Despite the significant change in the bony naso-pharynx (PNS-Ba) in this study, all the other studied variables for upper nasopharyngeal airway were not affected significantly. This might be due to the adaptive ability of the soft palate to perform velopharyngeal closure function.

A significant reduction was observed in the inferior uvulo-glosso pharyngeal air way dimensions, in which McNamara's lower recorded a mean reduction of 1.13mm and also the IAS recorded a mean reduction of 1.06mm. This was in disagreement with Valiathan *et al.* (2010) and Germec-Cakan *et al.* (2010).

The possible underlying cause for the reduction in the lower air way dimensions may be due to the backward downward rotation of the mandible since the treatment was non extraction. (Akcam *et al.*, 2002; Freitas *et al.*, 2006)

In this study, the main way for gaining the space was by arch expansion especially in the upper arch. This arch expansion in addition to a bio-extrusive mechanics of the fixed appliance treatment might have resulted in a backward down rotation of the mandible, which in turn reduced the lower air way dimension, and increased the vertical dimension of the oropharynx significantly.

Arch expansion in non extraction group was responsible for inferior uvulo-glosso pharyngeal air way reduction; this was in contrary to other studies which claimed that arch expansion would result in increasing the air ways dimensions. (Buccheri *et al.*, 2004; Palaisa *et al.*, 2007).

Soft tissue measurements; including tongue length and height, soft palate length and height did not change significantly. These findings are in agreement with that reported by Germec-Cakan *et al.* (2010).

Hyoid bone position was also not affected significantly in this group. This was in agreement with that reported by Germec-Cakan *et al.* (2010).

#### **6.2.2.2 Dental cast changes**

In this group, arch length was not affected significantly. This finding was expected, since one of the inclusion criteria for sample selection was absence of the crowding or spacing according, no change had occur by retraction or proclination of teeth

In the upper arch, inter-canine, inter-premolar and inter-molar widths have increased significantly. This was in agreement with Isik *et al.* (2005).

In this study, the highest value of width increase was recorded for inter-first premolar, followed by inter-second premolar width, which was in agreement with the results reported by Sadowsky *et al.* (1994).

The least, but still significant, change was for the inter-canine width which was in agreement with that reported by Isik *et al.* (2005).

The increase in the arch width is possibly due to the non extraction treatment of the mild crowding, in which the required space was provided by the arch expansion.

In the lower arch, only inter-second premolar width was increased significantly with a mean increase of (1.02 mm). This was in agreement with other previous studies (Isik *et al.*, 2005; Kim and Gianelly, 2003). The possible explanation for this increase in the lower



inter-second premolar width may be due to a high percentage of lingually tilted lower second premolars as a result of early extraction of the primary second molar teeth. These lingually tilted premolars get up righted following orthodontic treatment resulting in an increase in the inter-premolar width.

Lower inter-first premolar, inter-molar, and inter-canine widths were not affected significantly. BeGole *et al.* (1998) reported a non significant increase in the lower inter-canine width following non extraction treatment. This may be related to the arch customization and the aims not to change the arch width for stability purposes.

### **6.3 Limitations of the study:**

- Small sample size, the overall number of the studied sample was 70 cases, taking into consideration the difficulty in collecting full records (pre and post- orthodontic treatment cephalograms and dental casts) for each patient.
- Using lateral cephalograms to assess airway dimensions; this provides a two dimensional image, while the airway is a three dimensional object.
- The effect of treatment duration was not taken into consideration, as it is known that non extraction treatment takes usually less time of treatment.

## **6.4 Conclusions**

- Premolar extraction for the treatment of bimaxillary proclination does not affect the upper airway dimensions.
- Non extraction treatment would expand the upper arch significantly.
- Arch expansion due to non extraction treatment did not increase the sagittal airway dimensions.
- Arch expansion due to non extraction treatment reduced the inferior uvulo-glossopharyngeal airway dimensions significantly.
- Hyoid bone position was not affected by extraction or non extraction treatment of bimaxillary proclination.

## **6.5 Recommendation for further research**

- Studying larger sample size with different age groups.
- Utilizing new techniques like C.T or CBCT for measuring the three dimensions of the airway, or rhinomanometry to measure the airway function and resistance.
- Determination of the used anchorage during the space closure (maximum or minimum).

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## Appendix A

### Ethical approval provided by Jordan University of Science and Technology Institutional Research Board (IRB)



جامعة العلوم والتكنولوجيا الأردنية  
Jordan University of Science and Technology



مستشفى الملك المؤسس عبدالله الجامعي  
King Abdullah University Hospital

#### لجنة البحث على الإنسان Institutional Review Board

Ref: .....

الرقم: 2010/1 جلسة 11 تاريخ 2010/4/28

Date: .....

التاريخ: ..... هـ

الموافق: ٢٠١٠/٥/٢٠ م

الأستاذ الدكتور عميد كلية طب الأسنان المحترم  
جامعة العلوم والتكنولوجيا الأردنية

تحية طيبة وبعد،،،

إشارةً إلى كتابكم رقم ط س 335/720/7 تاريخ 2010/3/18 والمتضمن عرض البحث المقدم من  
الدكتور عماد فرحان المعاينة والطالب نزار جواد عبد الجليل السعيد بعنوان:

#### Effect of premolar extraction on upper airway dimension in patients with bimaxillary proclination

يرجى إعلامكم بموافقة لجنة البحث على الإنسان على إجراء البحث العلمي المشار إليه أعلاه، على أن  
يتم التقيد بالشروط التالية:

1. الحفاظ على سرية المعلومات وأن لا تستخدم إلا لغايات البحث العلمي.
2. لا يحتاج البحث إلى نموذج تفويض من المشارك.
3. تزويدنا بنسخة من نتائج البحث.

وتفضلوا بقبول فائق الاحترام،،،

رئيس لجنة البحث على الإنسان

الأستاذ الدكتور محمود الشيايب

رئيس اللجنة الطبية

أستاذة

نسخة: قسم السجلات الطبية  
ث.أ. / منسق اللجنة الدائمة

أ.أ. /

## تأثير قلع الضواحك الأولى على أبعاد الممرات الهوائية العليا في علاج مرضى بروز الفكين

إعداد: نزار جواد السعيد

### الملخص

الهدف من هذه الدراسة هو تقييم تأثير خلع الضواحك الاولى في علاج حالات بروز الفكين على ابعاد الممرات الهوائية العلوية .

ضمت هذه الدراسة ٧٠ مريضاً تراوحت اعمارهم بين ١٨-٢٣ سنة، تم تشخيصهم كمرضى بروز الفكين، والذين تم تقسيمهم الى مجموعتين ، المجموعة الاولى و تضم ٣١ مريض تم علاجهم عن طريق خلع الضواحك. المجموعة الثانية (المقارنة) و تتكون من ٣٩ مريض تم علاجهم تقويميا بدون خلع اسنان.

تم توفير قوالب جبص و صور شعاعية جانبية للرأس قبل المعالجة و بعد المعالجة لكل مريض، و تم عليها قياس عدد من الزوايا و المسافات مخصصة لقياس الممرات الهوائية العلوية.

النتائج الاحصائية للمجموعة الاولى اوضحت نقصان في طول اللسان و سمك الانسجة الخلفية للممرات الهوائية، و زوايا انحناء الاسنان الامامية بالمقارنة مع عظم الفك و الانسجة الاخرى. و نقصان في طول الفك السفلي، و المسافة بين الرحي الاولى.

اما بالنسبة للمجموعة الثانية فقد اظهرت النتائج نقصان في الجزء السفلي من الممرات الهوائية، بينما سجلت زيادة في الارتفاع و في الحجم العظمي للممرات الهوائية الخلف انفية.

نستنتج من الدراسة ان خلع الضواحك الاولى لعلاج مرضى بروز الفكين لا يؤثر على ابعاد الممرات الهوائية العلوية. اما بالنسبة للعلاج بدون خلع فانه يؤثر على زيادة توسعة الفك، و التي بدورها تقلل مسافة الجزء السفلي من الممرات الهوائية.



